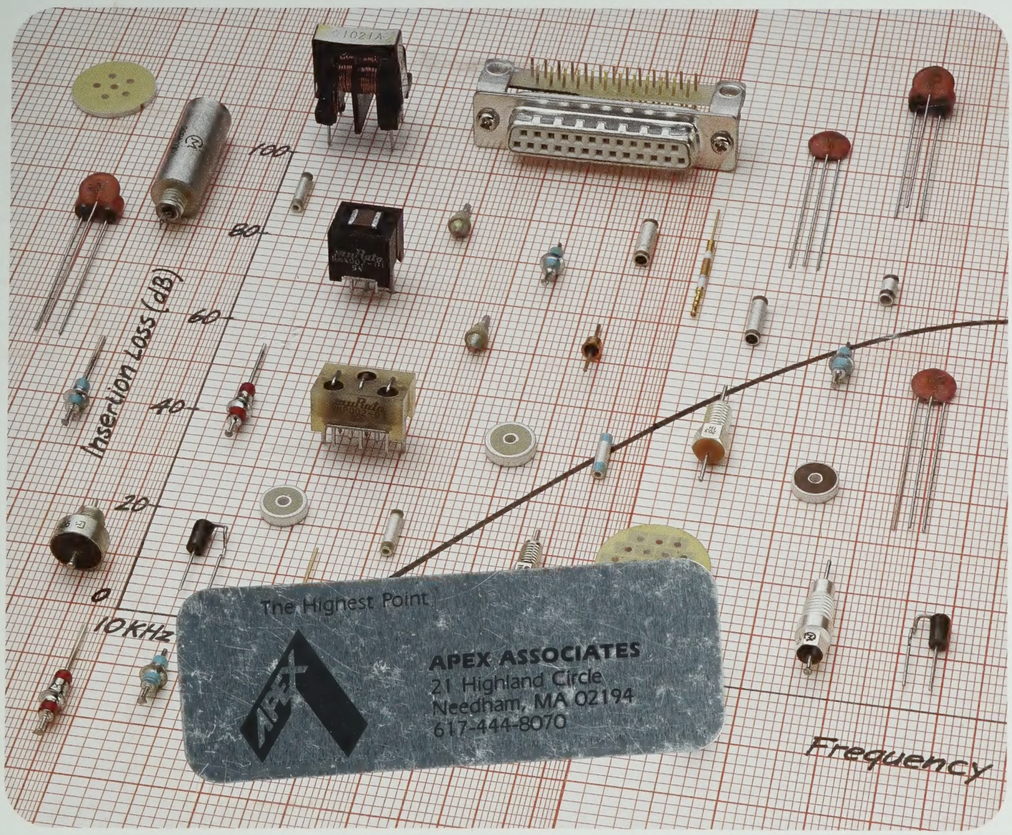
EMI FILTER APPLICATION MANUAL

CATALOG NO. 61-08



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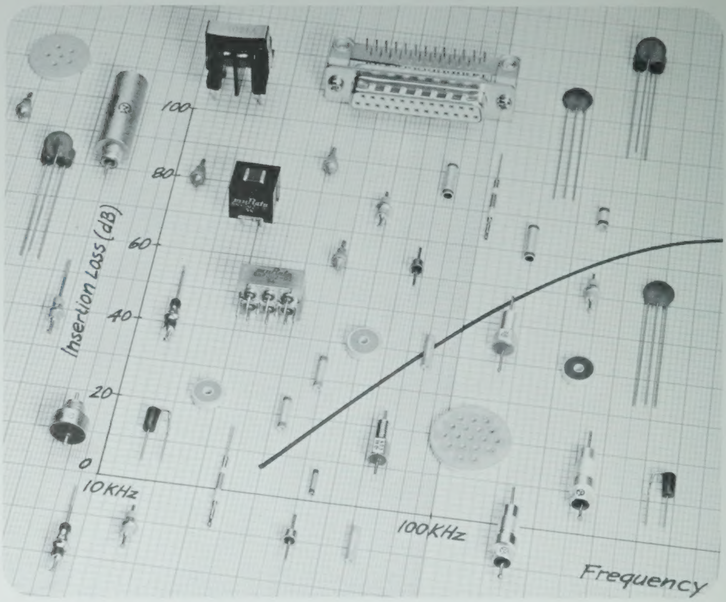


Murata Erie is an EMI Filter manufacturer dedicated to the design and production of high quality EMI filters and filtering systems for the electronics industry. In-house facilities include a complete design and manufacturing capability for EMI filters, a Quality Assurance System meeting or exceeding the requirements of MIL-Q-9858 and DND-1015, and a fully equipped and qualified calibration laboratory. To compliment this design and manufacturing expertise, Murata Erie has a complete Customer Service and Customer Engineering staff that offers comprehensive customer application assistance.

The information contained in this manual is designed to provide the engineer with a guide to the elimination of EMI/RFI as well as a description of standard measuring techniques. For additional information or application assistance, contact your local Murata Erie Sales Office or our Customer Engineering Departments in Trenton, Ontario, Canada at 613-392-2581.

EMI —
ELECTRO MAGNETIC INTERFERENCE

DEFINITION:

EMI is unwanted signals which are radiated or conducted to susceptible equipment and interfere with the performance of that equipment.

The effects of EMI vary from — static on a car radio, to a malfunction of an aircraft navigation system, or incorrect readouts on hospital equipment.

SUMMARY

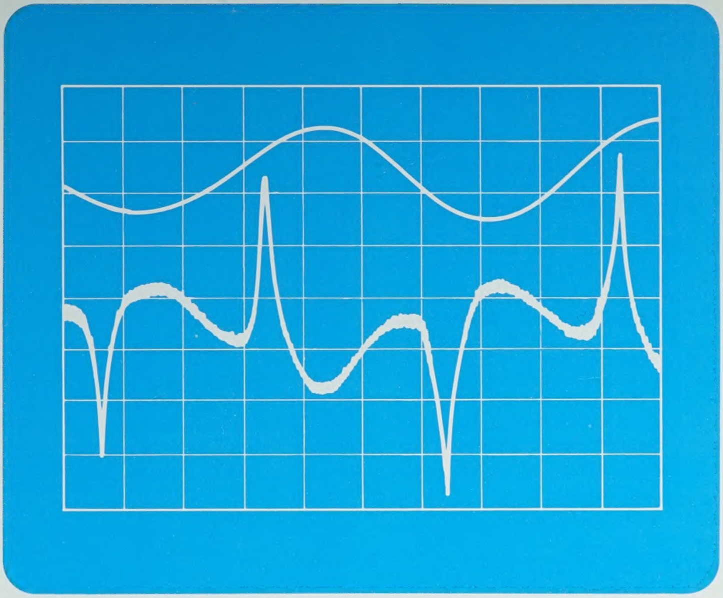
In selecting and installing EMI filters, the following parameters must be considered to ensure the correct filter is used.

(a) Selection

1) Working voltage — AC or DC
2) Current
3) System Impedance
4) Temperature range — operating and storage
5) Environment
6) Size and weight
7) Application — Military or Commercial
8) Insertion Loss

(b) Installation

1) Input/Output Isolation
2) Grounding
3) Proper torque/solder temperatures



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SOURCES OF EMI

TYPES OF INTERFERENCE:

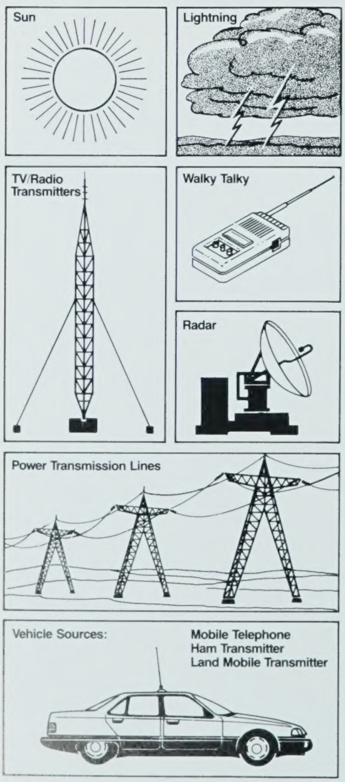
Common Mode:
Common Mode EMI can be defined as noise which is present on both the line and neutral paths with respect to ground.

Differential Mode:
Differential Mode EMI can be defined as noise which is present as a voltage between the line and neutral leads.

SOURCES OF EMI:

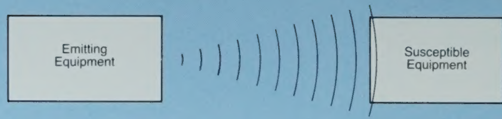
Continuous EMI comes from auto ignitions, switching power supplies, microwave devices, radio transmitters, motors and clock oscillators in digital equipment. Examples of EMI are seen every day, such as a vacuum cleaner which affects a TV set, a pocket calculator which is picked up by an FM radio, and an ignition noise from a car picked up on another car's radio.

Intermittent EMI comes from lightning discharge, switching on and off of inductive loads, electrostatic discharges and equipment such as RF soldering devices or electric welders.

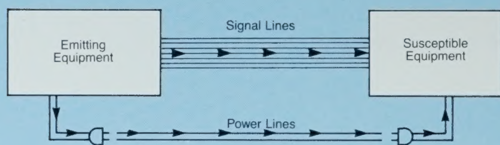


PROPAGATION MODES

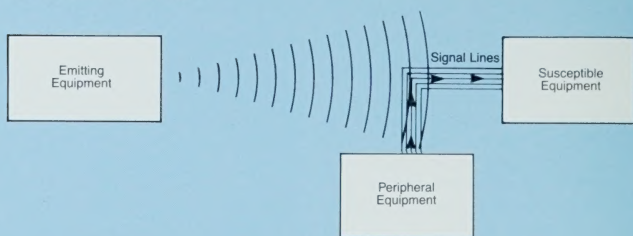
Radiated Emissions



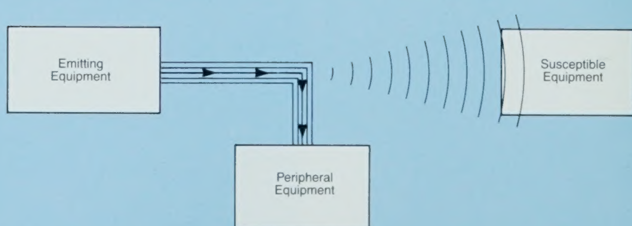
Conducted Emissions



Radiated Conducted



Conducted Radiated



EMI suppression can be accomplished by:

Source Suppression:
This involves designing the circuits and PCB's to reduce the amount of EMI that is produced by internal components and circuitry. This includes reducing ground loops and common mode noise by increasing PCB paths, de-coupling power buses, eliminating radiating leads and re-designing particularly noisy circuits.

Shielding:
Shielding attenuates radiated interference, therefore it is important for both susceptibility and emission requirements. Shielding may be accomplished by spraying conductive material on the inside of plastic containers, using foil on leads, or enclosing noisy circuits in metal boxes.

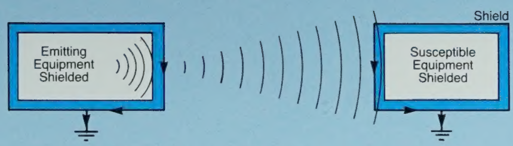
Filtering:
Filtering is used to reduce conducted emissions which is accomplished by using filters on powerlines, signal lines (filtered connectors) on the PCB as bypass filters for IC's, or inductors on ground wires.

By filtering, conducted EMI can be reduced, which in turn prevents the noise from being radiated from powerlines.

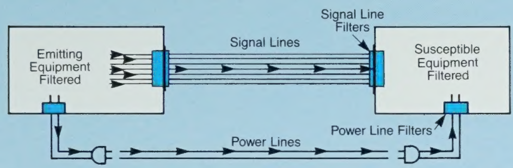
Care must be taken to filter from the signal lines to ground and not the 0 volt line; as this may create even more EMI problems by injecting the noise into the 0 volt line, which will set up a current and find its way back into the circuit.

METHODS OF SUPPRESSION

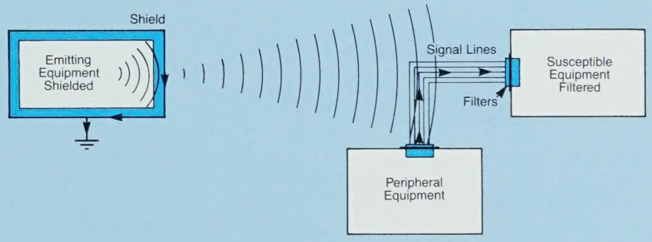
Radiated Emissions — Shield



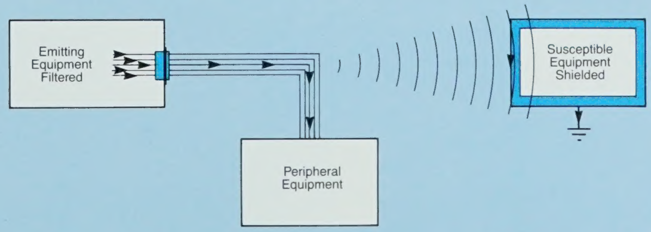
Conducted Emissions — Filters



Radiated Conducted — Shield/Filters



Conducted Radiated — Filter/Shield



UNDERSTANDING LOW PASS FILTERS

Before selecting a low pass filter, the terminology used in the filter world must be understood.

Many of the terms are common to all kinds of electronic components and circuitry, but a review of terms used for filters and capacitors may help the EMI Engineer understand the application information contained in this manual. Some common terms are:

1. Insertion Loss:
I.L. is the effectivity of a filter and I.L. is described as a ratio of voltages across the load with and without the filter in the circuit. In specifying filter performance, the government created MIL Std 220 to ensure that I.L. testing was performed the same way by all suppliers. This system has a 50 ohm input and load, and states that full load testing (that is with current applied through the filter which loads the inductors) will be performed between 100 KHz and 20 MHz only.

2. Feed-thru (See Figure 1)
This describes a mechanical configuration where the signal line feeds through and is surrounded by the ground termination.

The advantage of this style of capacitor (or filter) is the isolation from input to output which is afforded by the capacitor body itself. The second advantage is the extremely short ground path from the electrodes to chassis ground.

Generally, in filter terms, feed-thru means a feed-thru capacitor only and this is the cause for confusion.

3. Tempest
The potential dissemination of intelligence through radiated or conducted emissions by equipment involved in the processing of classified or sensitive information.

This can apply to government agencies, military and industry alike.

4. Decibel (dB)
This unit is used to provide an easy method of stating large ratios. The decibel is particularly useful when comparing large ratios of voltage as is the case with attenuation or amplification.

For voltage, dB is stated as $20 \log_{10} \frac{V1}{V2}$

Examples of dB are where V2 = 1 Volt

If —

$V1 = 2;\ \frac{V1}{V2} = \frac{2}{1} = 2\ \therefore$
$20 \log_{10} 2 = 6$ dB above 1 volt

$V1 = 3;\ \frac{V1}{V2} = \frac{3}{1} = 3\ \therefore$
$20 \log_{10} 3 = 10$ dB above 1 volt

$V1 = 10;\ \frac{V1}{V2} = \frac{10}{1} = 10\ \therefore$
$20 \log_{10} 10 = 20$ dB above 1 volt

$V1 = 100;\ \frac{V1}{V2} = \frac{100}{1} = 100\ \therefore$
$20 \log_{10} 100 = 40$ dB above 1 volt

$V1 = 1000;\ \frac{V1}{V2} = \frac{1000}{1} = 1000\ \therefore$
$20 \log_{10} 1000 = 60$ dB above 1 volt

The advantage of using dB is when two large numbers must be multiplied. By changing those numbers to dB they can be added and vice versa.

For example, 2000 becomes 20 log 2 (6 dB) plus 20 log 1000 (60 dB) which is 66 dB.

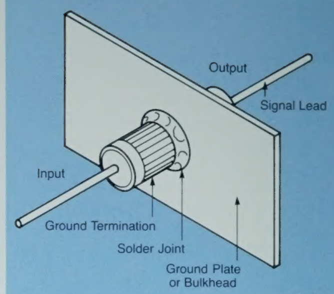
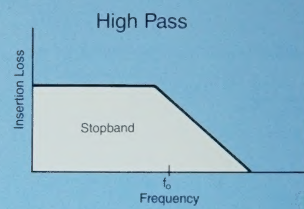
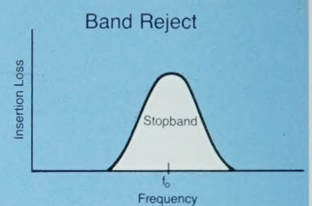
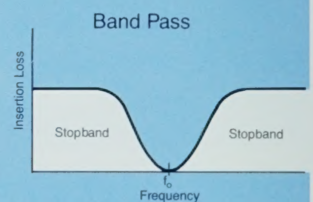
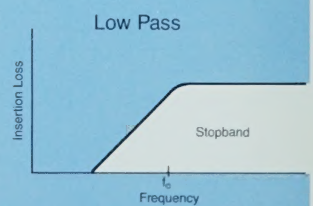


Figure 1. Feed-thru.





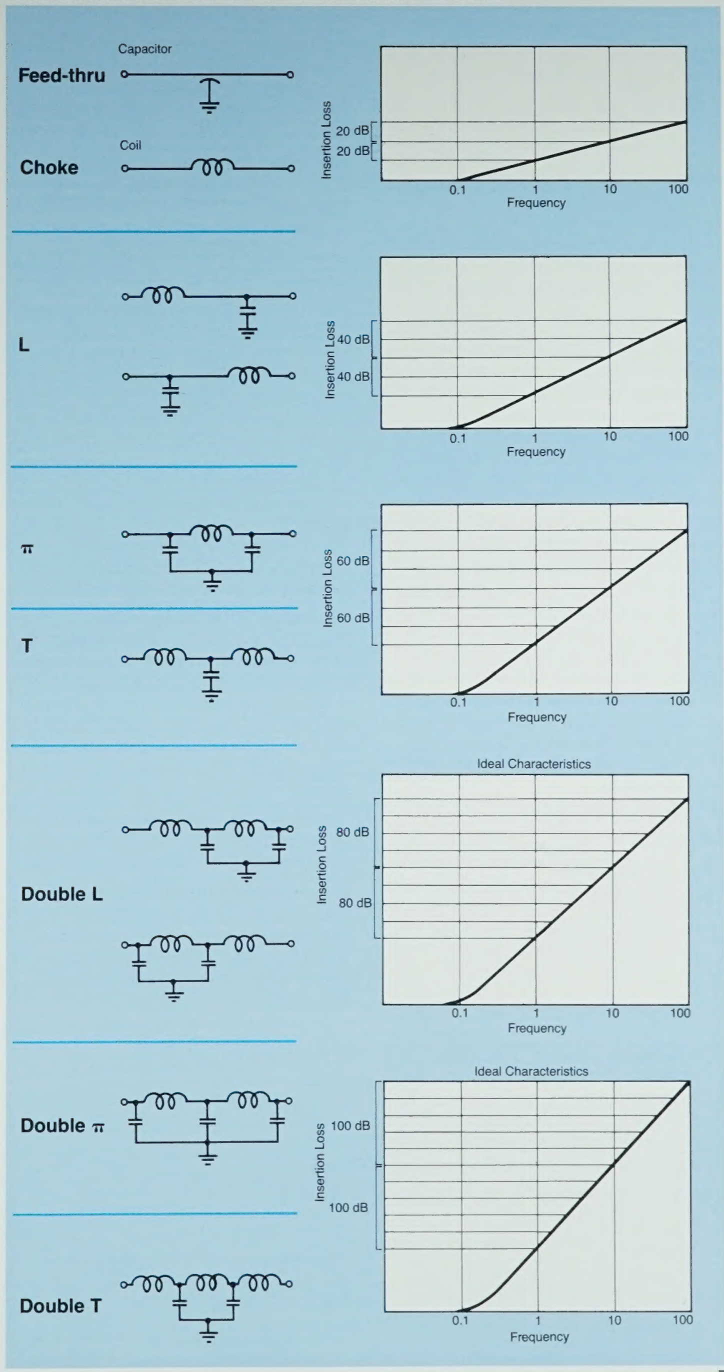




CIRCUIT CONFIGURATIONS OF EMI FILTERS

For each section (capacitive or inductive element) which is added to a filter, the resultant Insertion Loss is increased by 20 dB per decade in a MIL-STD-220 50 ohm system. The filtering achievable is also limited by inductance and resistance in the capacitor and parasitic capacitance and resistance in the inductor. The result is that the I.L. of a filter "levels off" at approximately 60 to 80 dB.

THE BASIC CIRCUITS OF LOW PASS FILTERS



FILTERING CAPACITOR CHARACTERISTICS

Capacitor:
The common terminology in capacitors is:

Capacitance — which is the ability to store energy. The formula for capacitance is —

$$C = \frac{KA\,(N-1)}{t}$$

where C = capacitance
K = dielectric constant
A = area of overlap of electrodes
N = number of electrodes
t = thickness of dielectric

The importance of this formula is that it describes the tradeoffs in capacitors. For example, for higher capacitance the dielectric constant can be raised (results in poorer temperature coefficient), the size of electrodes can be increased and/or the number of electrodes can be increased, which both result in larger mechanical sizes or the thickness of the dielectric can be decreased, which lowers the working voltage also.

Temperature Coefficient — TC
The temperature coefficient is the change in capacitance which occurs over the temperature range. Generally speaking, most capacitors decrease in capacitance at high temperatures 85°C or 125°C and this usually becomes more noticeable as the dielectric constant increases.

The EIA have standardized on the following TC's.

Low Temperature Requirement	Letter Symbol
−10°C	Z
−30°C	Y
−55°C	X

High Temperature Requirement	Numerical Symbol
+45°C	2
+65°C	4
+85°C	5
+105°C	6
+125°C	7

Max. Capacitance Change Over Temp. Range	Letter Symbol
+1.0%	A
±1.5%	B
±2.2%	C
±3.3%	D
±4.7%	E
±7.5%	F
±10.0%	P
±15.0%	R
±22.0%	S
+22%-33%	T
+22%-56%	U
+22%-62%	V

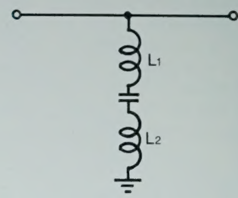
Example
Z5U means the capacitance can change +22% − 56% over a temperature range of −10°C to +85°C.

Insulation Resistance — IR
The IR of a capacitor is the resistance of the dielectric material. This is measured by imposing 100V or the working voltage of the capacitor (whichever is less) on the capacitor and measuring the current that actually leaks through the capacitor. This is then converted to ohms.

The higher the IR the better, as less current will be used in a circuit and less heating of the capacitor will occur.

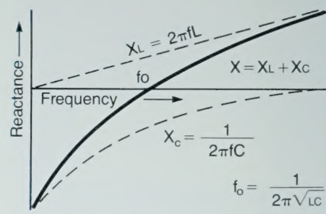
Unfortunately, capacitors are not ideal components. There is inductance and resistance associated with capacitors and the amount of these values can greatly affect the performance of the filter.

PCB Capacitors
a) Two Leaded — The equivalent circuit of a two leaded capacitor used as a bypass filter is:

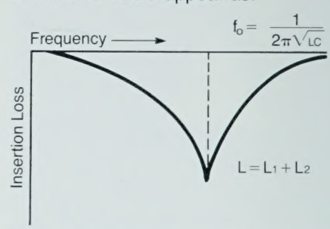


Equivalent Circuit

This creates a self resonance



and therefore the I.L. of this device would appear as:



The residual inductance of capacitors is dependent upon the electrode material and length of lead wires. The inductance varies between 1nH and 150nH.

RESIDUAL INDUCTANCE OF TYPICAL CAPACITORS

Capacitor Type	Series Inductance
Lead type Monolithic Ceramic Capacitor (0.01μF)	5 nH
Lead type Monolithic Ceramic Capacitor (1μF)	6 nH
Disk/Lead type Ceramic Capacitor (0.0022μF)	4.5 nH
Polyethylene Telephthalate Film Capacitor (0.03μF)	9 nH
Mica Capacitor (0.01μF)	52 nH
Polystyrene Film Capacitor (0.001μF)	12 nH
Polystyrene Film Capacitor (0.1μF)	100 nH
Tantalum Electrolytic Capacitor with Solid Electrolyte (16μF)	5 nH
Aluminum Electrolytic Capacitor (For RF use) (470μF)	13 nH
Aluminum Electrolytic Capacitor (470μF)	130 nH

SELECTING A FILTER

Selection of an appropriate filter is dependent upon the circuit's electrical characteristics, insertion loss requirements, (including cutoff frequency and upper frequency limit of stop band), environmental requirements and real estate limitations within the equipment.

All of these factors will impact performance, availability and cost.

The selection process then becomes a check list —

1. Application
Environmentally Ruggedized
- Space
- Military
- Industrial

Non Ruggedized
- Military
- Commercial

This determines the mechanical requirements of the filter. For example, in military applications where the equipment will be airborne, shipboard or field equipment, the filter may see high vibrations, extreme temperatures, high ambient moisture or chemicals and a filter designed for these harsh environments must be used.

In more controlled environments such as computer rooms, households and office areas, the use of hermetically sealed or ruggedized filters is not necessary.

2. Electrical Characteristics
It is necessary to determine if the filter will be used on AC mains and if so, are there maximum leakage current requirements.

Another important consideration in powerline filter selection is the probable existence of spikes, surges or transients on powerlines. It is therefore recommended that an inductive input filter (L or T) be used in this situation. The inductor will "see" the spike first and attenuate it somewhat, providing a degree of protection for the capacitor which is much more susceptible to transients.

If the circuit the filter is to be used in is DC, then simply select a filter with an appropriate DC voltage rating.

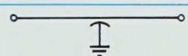
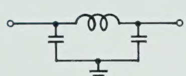
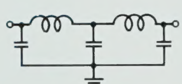
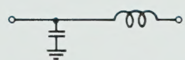
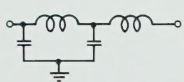
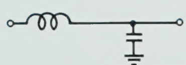
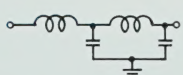
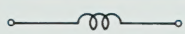
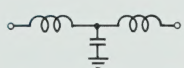
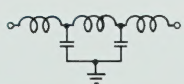
The next parameter to determine is the current in the circuit. The current rating determines the size of inductors that can be used in a filter which affects the I.L. and size of the filter.

Both the voltage rating and current rating will inversely affect the I.L. because in a given size as voltage and current increase, capacitance and inductance decrease.

Circuit impedance will determine the style of filter. The rule of thumb is to ensure a capacitor in the filter faces a high impedance and an inductor sees a low impedance. The reason is that as the frequency of interference increases, Xc decreases. Therefore, the noise will be looking at a mismatch, which will shunt the EMI to ground (path of least resistance) and the opposite is true for an inductor. X_L increases with frequency, therefore providing a mismatch between the inductor and the low impedance.

The following chart shows the type of filter that is best suited to different input and output impedances. Low impedance is 50Ω or less.

I/O IMPEDANCE AND SELECTION CRITERIA

		Output Impedance (Z_o)	
Input Impedance (Z_i)		High	Low
	High	 Capacitor  π Type  Double π Type	 L Type  Double L Type
	Low	 L Type  Double L Type	 Coil  T Type  Double T Type

SELECTING A FILTER

When selecting the correct style to use, there are several trade-offs to be taken into account, which are —

1. Each additional element improves the slope of the I.L. That is, the stop band will be reached much faster with each section added. (See Figure 2.)

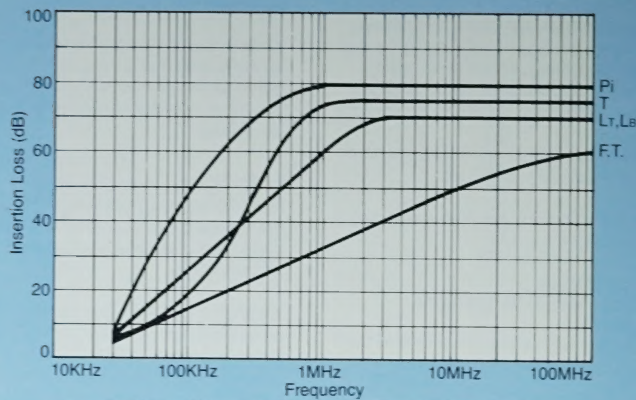
2. Each additional element usually adds cost, weight and size.

3. Adding capacitance or inductance does not change the slope of insertion loss but increases or decreases the cutoff frequency. (See Figure 3.)

4. More importantly, when the impedance of the circuit changes, I.L. slope does change. A π type filter for example is best sujted to a system that has a high impedance on each side but when those impendances become lower, the I.L. also becomes lower.

If the circuit impedance varies, then it is advantageous to use a multiple section filter, such as a π type filter. With a π type filter, if the impedance of the system is high then the filter works to its maximum; if one impedance is reduced, the filter still has 2 elements that function effectively.

If both input and output impedances are reduced, the π filter still has one element (the inductor) which is functioning properly. Compared to a feed-thru capacitor, which in a low impedance system becomes much less effective, the π type filter is a better choice. (See Figure 4.)



I.L. Versus Frequency (For Various Filter Configurations)

Figure 2.

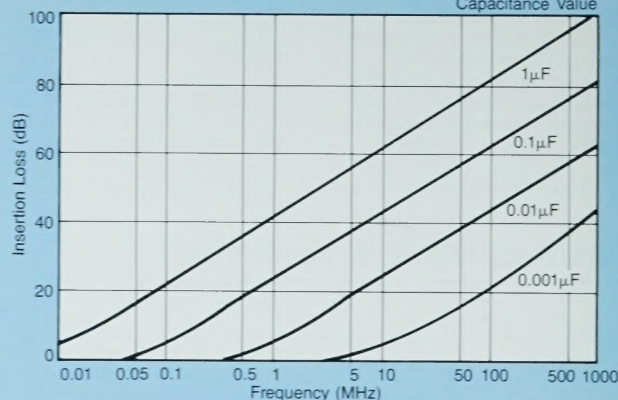


Figure 3.

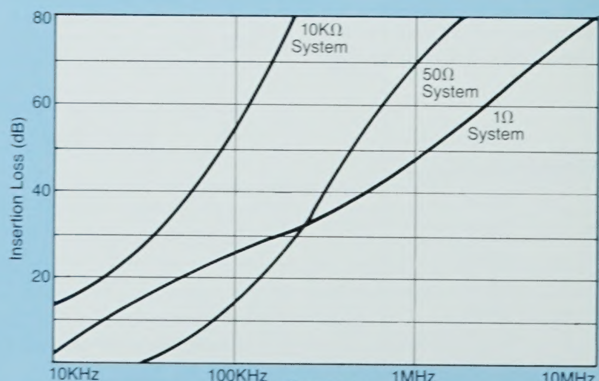


Figure 4. I.L. Versus Impedance

3. Insertion Loss
a) Stopband

Military requirements are usually much higher in frequency (up to 10GHz), whereas the commercial FCC type requirements are in the 100MHz area. Because of these requirements, certain types of filters are not suitable for military, aerospace and industrial use.

The differences in construction of military and commercial filters are:

i) Military filters require better isolation because of frequency ranges they must work in. In other words, input to output isolation must be maintained by the use of feed-thru type capacitors (not leaded devices) and/or ground planes within filters to

compartmentalize components, thus providing the required isolation.

ii) Use of soldered connections between the filter and line/ground is necessary for military applications, again because of the high frequencies involved. Ground connections must be as short as possible and as low in resistance as possible, to provide the necessary high frequency performance.

b) Cut Off Frequency (fco)

When dealing with power lines the fco is very low — 1KHz for 60Hz lines, 10KHz for 400Hz lines, and as low as possible for DC lines. In contrast to this, signal lines must be treated with care. The frequency of the signal must be known and a cut off frequency must be selected which is usually one decade above. This will prevent wave shaping of digital signals.

In this case circuit impedance becomes important. When a filter is selected from the catalog, the insertion loss is specified in a MIL-STD-220 (50 ohm) system. As the impedance of the circuit increases, the insertion loss will increase with a capacitive input output filter and decrease with an inductive input/output filter. (See Figures 5 and 6.)

For example, a 100pF feed-thru capacitor is ideal for a cut off frequency of 10MHz which would be selected to pass a 1MHz data rate. However, if the system impedance is 600 ohms, the insertion loss goes from 5dB to 25dB at 10MHz and the cut off frequency becomes approximately 500KHz. This would certainly attenuate the 1MHz signal. (See Figure 7.)

c) Impedance Systems Other Than 50

To determine the performance of a filter which has I.L. specified in a MIL-STD-220 50 ohm system in a system other than 50 ohms, the following transfer impedance graph may be used. (See Figure 8.)

Example:

1. System impedance is 100 ohms input and 600 ohms output.
2. Selected filter is 1214-172, which is 1750pF and has an I.L. of 50dB at 100MHz in a 50 ohm system.
3. To calculate the I.L. in the actual system, the following formula must be used.

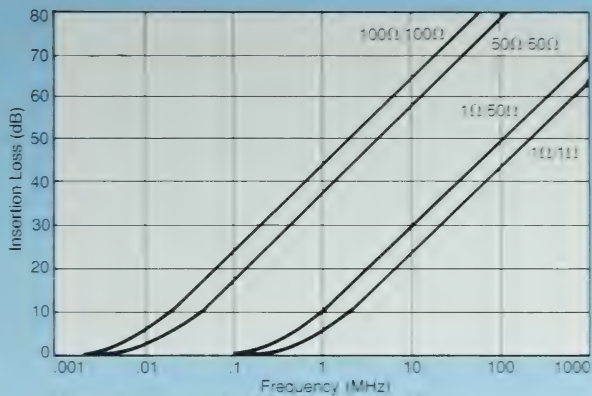


Figure 5. Feed-thru Capacitor (.5μF)

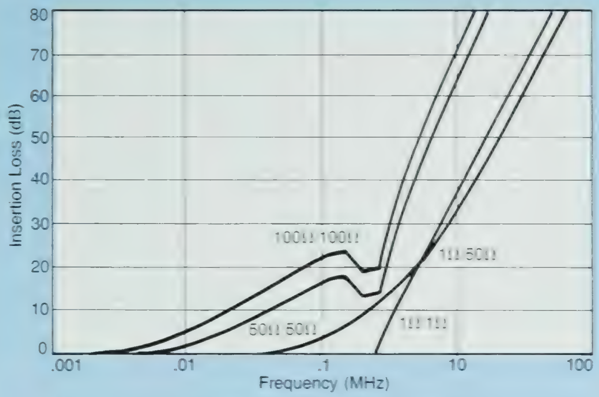


Figure 6. π Style Filter (.25μF, .4μH, .25μF)

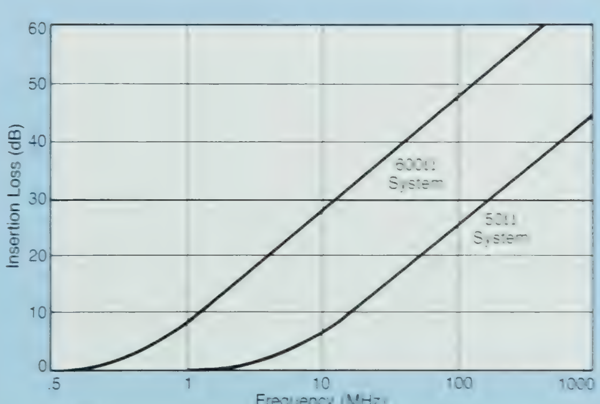


Figure 7. 100 pF Feed-thru

I.L. (dB) =

$$20 \log_{10} \left[1 + \frac{Z_S \; Z_L}{Z_{12} (Z_S + Z_L)} \right]$$

Z_S = Source Impedance (100 megohms)
Z_L = Load Impedance (600 megohms)
Z_{12} = Transfer Impedance
The transfer impedance is taken from the following graph and in this case the I.L. is 50dB. therefore the $Z_{12} = 8 \times 10^{-2}$ ohms.
The attenuation is then:
I.L. (dB) = 20 $\log_{10}$

$$1 + \frac{100 \times 600}{8 \times 10^{-2} (100 + 600)}$$

$$= 20 \log_{10}$$

$$1 + \frac{60.000}{56}$$

$$= 20 \log_{10} 1072$$

$$= 60.6\text{dB}$$

As can be seen, the 1214-172 will produce 60.6dB in the 100/600 ohm system at 100MHz.

Equipment Real Estate
In many military applications such as fighter aircraft and satellites, real estate and weight are critical considerations. This was the primary driving force in developing filter connectors or custom multi-line filters.

Even now, in commercial applications, with the ever decreasing size of electronic equipment and components, filter elements must also be reduced the same way. (See Figure 9.)

FILTERS AND FILTERING

Murata Erie manufactures many filter components such as filtercons (feed-thru type tubular ceramic filters), coaxials (feed-thru type multilayer discoidal capacitor filters), filter connectors (circular and D type), custom filters (any size, style or configuration desired), PCB filters (including three lead disc capacitors, ferrite beads, discs with ferrites, PCB mounted dual line filters, suppressor discs), ceramic capacitors (leaded and surface mount type for decoupling).

The following page lists the EMI filtering components manufactured by Murata Erie, with an outline drawing, features and the frequency range they are designed to be used in.

COMPARISON OF FILTER CONNECTOR VS FILTER PLATE

Figure 9 shows a block diagram of a piece of equipment utilizing a filter connector and another filtered by a ground plate with individual filters. Notice how much area is needed by the plate method, where the filter connector is generally only .75 inch longer than an unfiltered connector. Fewer solder connections and hook up wires are required further reducing weight, space and cost.

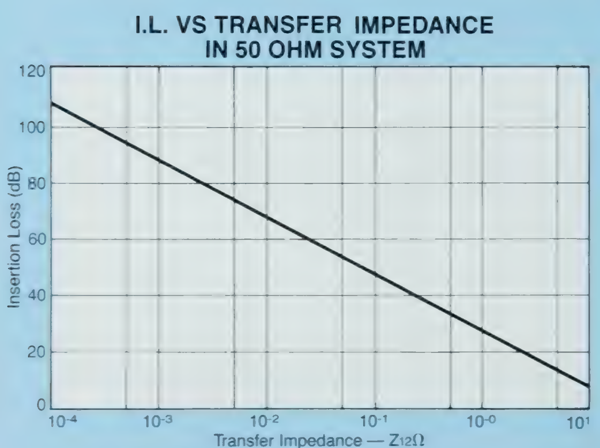


Figure 8.

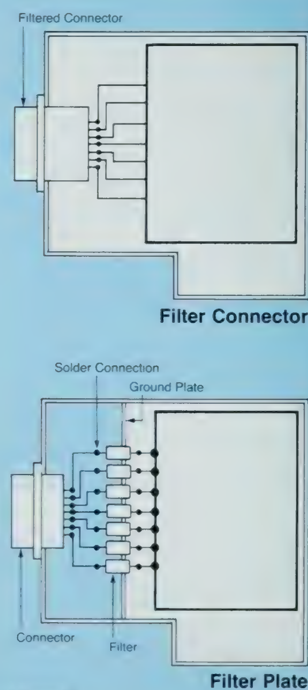
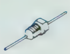
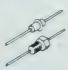
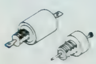
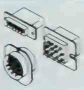


Figure 9.

FREQUENCY RANGE OF EMI FILTER COMPONENTS

CLASSIFICATION		STYLE	FREQUENCY RANGE (100KHz 1MHz 10MHz 100MHz 1GHz 10GHz)	FEATURES	CATALOG
BOARD MOUNTED DEVICES					
Disk Type DD		C		Eliminates EMI with upper limit of several tens of MHz Used for PCB decoupling	58-06
Monolithic Capacitor RPE		C		Eliminates EMI with upper limit of several tens of MHz Used for PCB decoupling	59-01
Capacitors SMD Chips Tubulars Planars		C		Suitable for EMI from several hundred KHz to 1GHz (Example) Military and commercial	59-01 60-05
Bead Inductor BL02		L		Suitable for eliminating subtle EMI to several hundred MHz (Example) Protection from radiation of digital equipment	59-08
3-Terminal Capacitor DS 310		C, T		Suitable for suppressing EMI up to several hundred MHz (Example) Digital equipment and car radio	59-08
3-Terminal Varistor Capacitor DSS 710		T		Suitable for suppressing EMI up to several hundred MHz and transients (Example) Digital equipment	59-08
π Type Block BNP		π		Suitable for suppressing EMI up to 1GHz (Example) Car electronics equipment and digital equipment	59-08
4-Terminal Block BNX		Network		Suitable for EMI counter-measures from several hundred KHz to 1 GHz (Example) Digital equipment	59-08
BULKHEAD MOUNTED DEVICES					
Disc Type DF 553 Barrier Layer DFT 304 NFT 403		C		Suitable for suppressing EMI higher than several tens of MHz (Example) General communications equipment and measuring instrument	59-08
Tubular 1200		L, π		Suitable for suppressing EMI from 1MHz to 10GHz (Example) Military, communications equipment, tempest	59-14
Monolithic Capacitor DFT 301 NFT 501 9900		C, L		Suitable for suppressing EMI higher than a few MHz (Example) Military and industrial electronic equipment	59-08 59-14
Monolithic Capacitor 9000		C, L, π, T		Suitable for suppressing noise higher than several hundred KHz (Example) Military airborne equipment, defense equipment and satellite equipment	59-14
Tubular Planar Filter Connectors Custom Filters		C, L, π		Suitable for suppressing noise higher than 1 MHz (Example) Commercial computers, military	59-12 CUB 25

INSTALLATION OF FILTERS

When installing filters, there are several criteria to remember, such as:

a) Grounding

Grounding the filter is extremely important because if there is any resistance between the capacitor and ground, the effectiveness of the filter diminishes with higher frequencies, as the impedance of the capacitor approaches zero and the ground resistance then becomes significant and shunts the noise through the filter instead of passing it to ground.

The recommended mounting torques and soldering instructions which are specified in the catalog must be adhered to, to prevent damage and to ensure a good ground path. (See Figure 10.)

b) Isolation

Isolating the input and output of a filter by installing it through a bulkhead is mandatory to prevent high frequency noise from skipping around or over the filter. (See Figure 11.)

Of course some filters are designed to be used on PCB's and consequently the high frequency effectiveness of this type of filter is reduced.

EXPERIMENTATION WITH EMI FILTERS

Theoretical analysis of EMI noise will normally identify the EMI source, but there can be no substitute for the practical application of devices employed *or* proposed for remedial measures.

Examples below are descriptions of and typical uses for experimentally investigating the effectiveness of EMI Filters.

1. Disc-type EMI Filter (DS310 series)

1-1. Disc-type EMI Filter as a general application:

First, cut that part of the PCB pattern that actually propagates noise and connect the lead wires found on either side of the disc-type EMI Filter (as shown in Figure 12). Next, connect the center lead wire, taking care to make it the shortest possible length (a maximum of 5mm) to either the stabilized ground pattern or to a frame ground.

Avoid using a long center lead like that shown in Figure 12.

1-2. Disc-type EMI Filter as a decoupling filter.

First, cut the IC power line PCB pattern, and jump the separated segments with a disc-type EMI Filter. Finally connect the center lead wire to a position closest to the ground terminal of the IC (as shown in Figure 13 a/b).

Caution: When using an EMI Filter for decoupling the power line (as shown in Figure 14), be very careful that no EMI route remains. All EMI noise routes must be filtered.

2. Block-type EMI Filter (BNP/BNX series)

As was done with the disc-type EMI Filter, first cut off the PCB pattern that actually propagates EMI, and then connect the lead wires to the cut pattern.

Since it is rather difficult to correctly position the grounds when experimentally using block-type EMI Filters, we suggest that you first prepare a sub-PCB containing linearly aligned grounds as shown in Figure 15; then

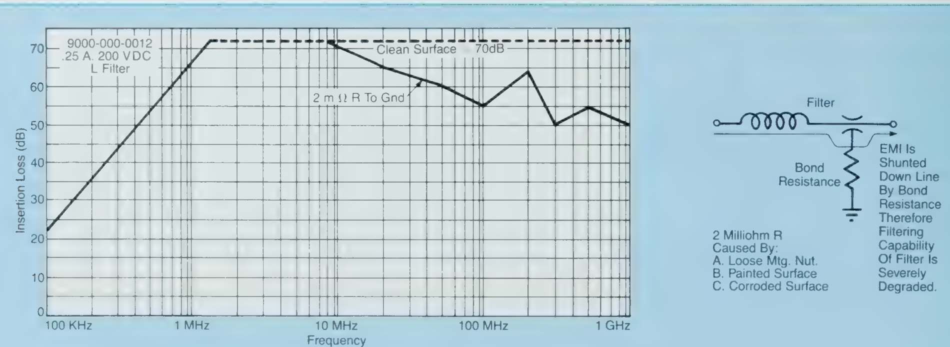


Figure 10. Results of Poor Ground.

FILTER INSTALLATION

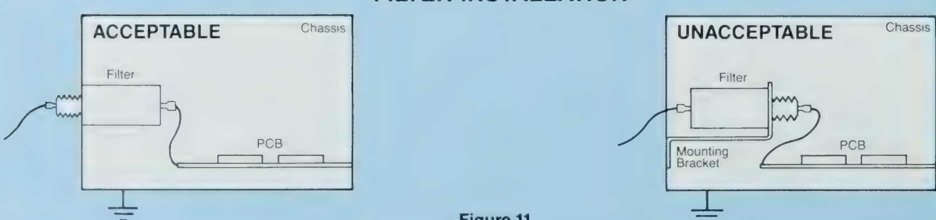


Figure 11.

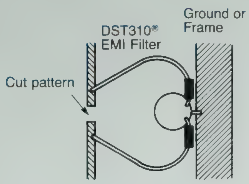


Figure 12. A typical example of disc-type EMI Filter use.

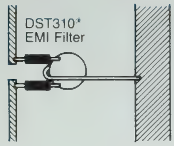
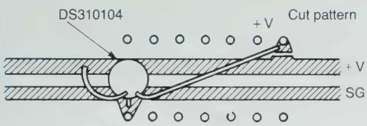
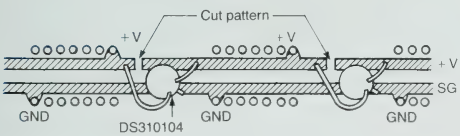


Figure 12. An example of incorrect use of disc-type EMI Filter.



(a) Decoupling an IC



(b) Decoupling the power line

Figure 13. Typical uses of EMI Filter as decoupling filters.

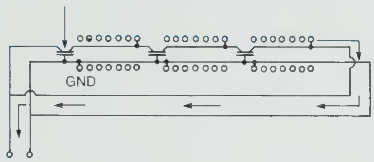
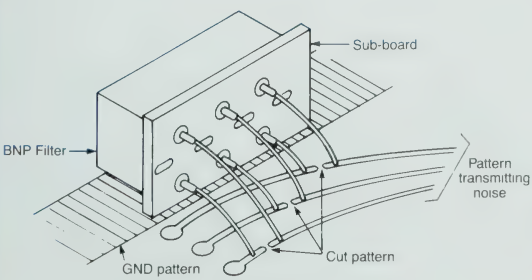
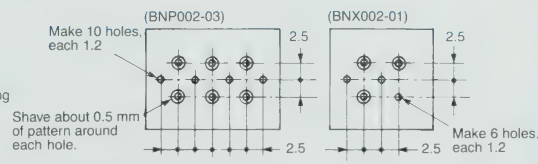


Figure 14. An example of incorrect decoupling. A noise route shown by arrows, remains unaffected by filters.



(a) A typical example using a block-type EMI Filter



(b) Typical patterns on the sub-PCB

Figure 15.

(Dimension shown in mm.)

connect the BNP filter to it before securely installing both the BNP filter and the substrate to the ground pattern.

The block-type EMI Filter BNX002-01 has a special construction containing four asymmetrical terminals, each having an inductor on the ground side. Therefore, be extremely careful when doing the following:

(1) BNX002-01 is directional. Be sure to connect the GND terminal with the inductor to the GND that is subjected to EMI entry. (See Figure 16.)

(2) All three GND terminals that directly extend from the GND substrate on the bottom surface of this filter play vitally important roles. Carefully connect these to the GND pattern on the circuit to prevent EMI entry. These may be connected to the frame GND.

(3) BNX002-01 effectively suppresses EMI that may enter via the ground; however, if the ground is connected to any portion other than the BNX, the EMI suppression effect will be lost. To prevent this, be sure to use an inductor as shown in Figure 17.

3. Precautions when EMI cannot be eliminated even after connecting an EMI Filter.

If EMI interference still remains unaffected even with an EMI Filter connected to the intended circuits, either of the following two conditions may exist.

(1) The EMI Filter itself is not grounded.

(2) An EMI route may exist in an unknown portion of the circuit other than that connected to EMI Filter.

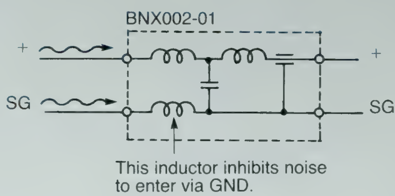
To deal with the first cause, try the following. (See Figure 18).

(a) Connect EMI Filter to the frame ground.

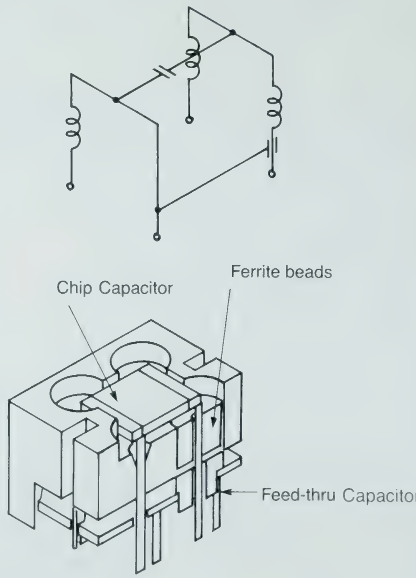
(b) Insert the bead inductor into the ground pattern.

(c) Will work effectively only when the ground pattern actually transmits EMI. Insert the bead inductor in the direction shown in Figure 18c.

To deal with the second potential cause, carefully determine the source without disconnecting the EMI Filters from the line. There may be other EMI routes. EMI suppression can be achieved only when all potential EMI routes are completely eliminated, even if the filter is properly installed.

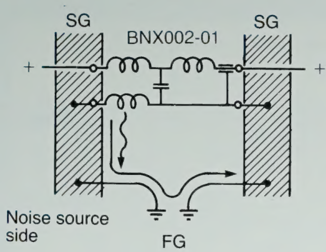


(a) A typical example using a BNX002-01

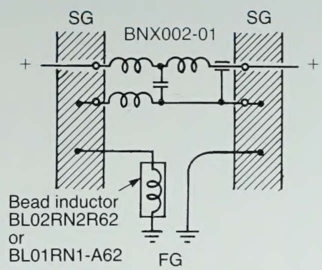


(b) Internal structure of BNX002-01

Figure 16.

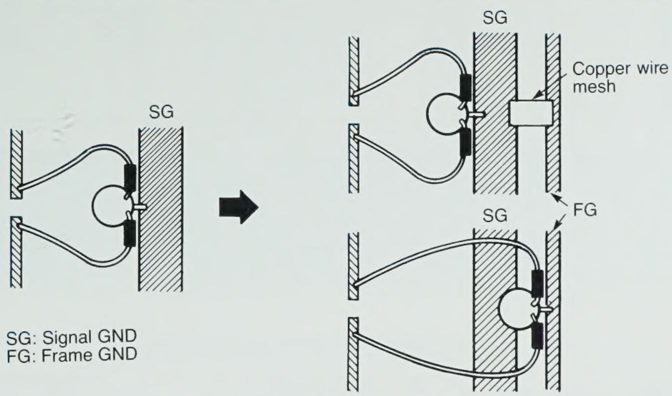


(a) A typical example of a noise route via the GND

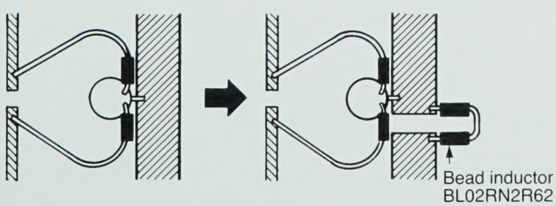


(b) A typical example of successfully improved noise cancellation using a bead inductor

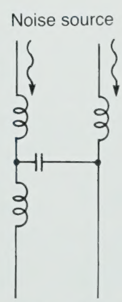
Figure 17.



(a)



(b)

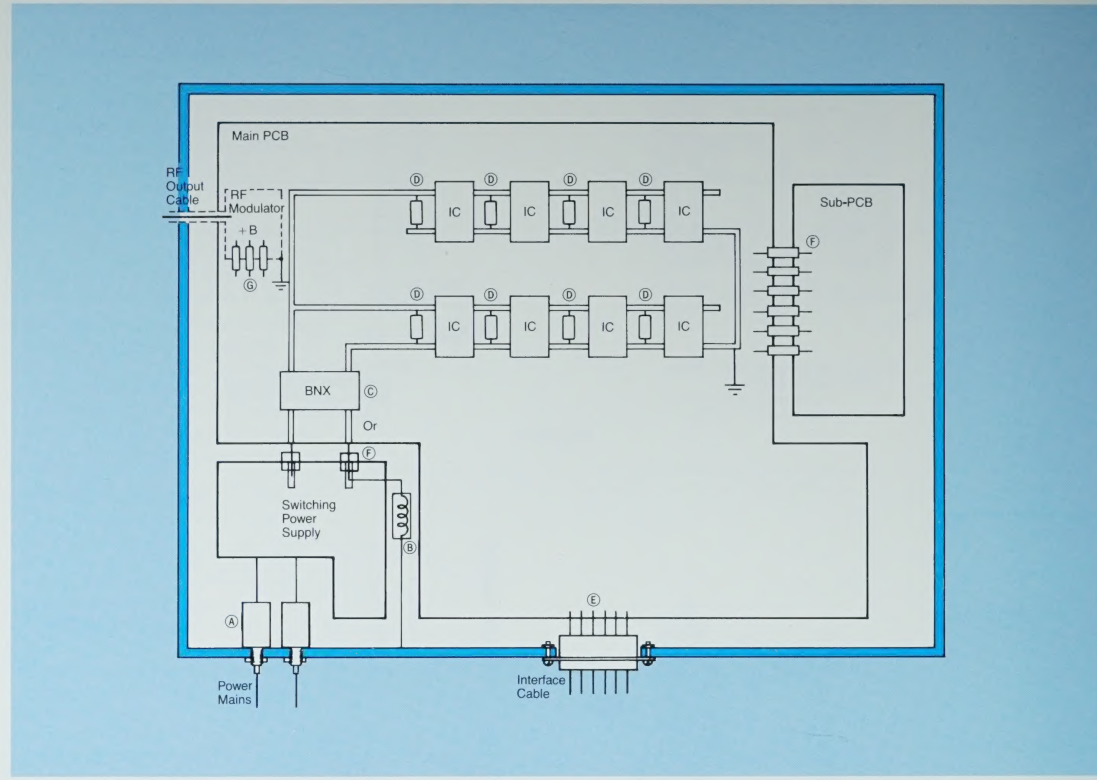


EMI will not be radiated if bead inductor is inserted in the ground nearest to the source, thus preventing EMI getting onto PCB ground trace.

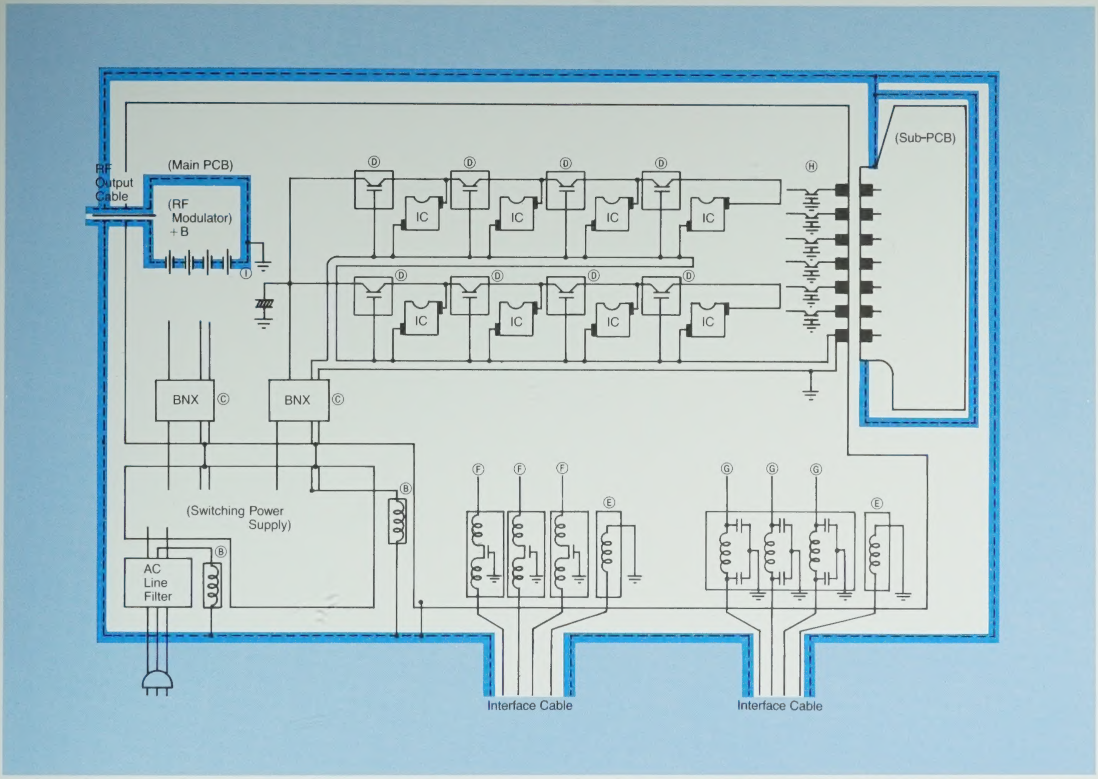
(c)

Figure 18.

APPLICATIONS
MILITARY EQUIPMENT



	Function	Function of Filter	Suggested Filter	Catalog
A	AC Line Filter	EMI suppressor between AC line and set	AC Line Filter or Custom Filter	59-14
B	Ground Inductor	EMI suppressor between chassis ground and either of AC line filter ground terminal, power supply ground or main PCB ground	Bead Inductor (BL02 and BL01)	59-08
C	DC Power Supply Filter	EMI suppressor between switching power supply and main PCB	Block-Type (BNX002)	59-08
D	Decoupling Filter	Decoupling among IC's, EMI suppressor for high frequency switching pulse	Disc-Type (DS310) or Chip Capacitor	58-06 59-08 60-04
E	Interface Cable Filter	EMI suppressor between interface cable and main PCB	Filter connector	
F	Sub-PCB Filter	EMI suppressor between sub-PCB and main PCB	Filtercon	59-14
G	RF Modulator Filter	To suppress leakage of local oscillator signals		59-14



SUGGESTED EMI FILTER APPLICATIONS FOR DIGITAL EQUIPMENT

	Function	Function of Filter	Suggested Filter	Taped and Reeled Availability
A	AC Line Filter	EMI suppressor between AC line and set	AC Line Filter	No
B	Ground Inductor	EMI suppressor between chassis ground and either of AC line filter ground terminal, power supply ground or main PCB ground	Bead Inductor (BL02 and BL01)	Yes
C	DC Power Supply Filter	EMI suppressor between switching power supply and main PCB	Block-Type (BNX002)	No
D	Decoupling Filter	Decoupling among IC's, EMI suppressor for high frequency switching pulse	Disc-Type (DS310)	Yes
E	S.G. Inductor	EMI suppressor between interface cable ground and main PCB ground	Bead Inductor (BL02 and BL01)	Yes
F	Interface Cable Filter (On Low Impedance Line)	EMI suppressor between interface cable and main PCB	Disc-Type (DS310, DST310)	DSS—Yes DST—No
G	Interface Cable Filter (On High Impedance Line)	EMI suppressor between interface cable and main PCB	Block-Type (BNP002)	No
H	Sub-PCB Filter	EMI suppressor between sub-PCB and main PCB	Disc-Type (DS310) Feed-Thru (TF240)	DS-Yes
I	RF Modulator Filter	To suppress leakage of local oscillator signals	Feed-Thru (TF240)	No

MURATA ERIE NORTH AMERICA

5 Fraser Avenue
Trenton, Ontario
Canada K8V 5S1
Tel: 613-392-2581
Telex: 06-62279
Panafax: 613-392-0701

Regional Sales Offices:
Northeast — 617-245-7880
Southeast — 407-644-0954
Southwest — 714-832-9972
Northwest — 503-646-4973
Western — 818-701-9702

Corporate Address: 2200 Lake Park Drive, Smyrna, GA 30080 (404-436-1300)

MU-3316-1189